Introduction

Computer-aided design, or CAD in short, is an engineering tool that combines the creativeness of the designers with the calculating and display power of computers. Going back to as far as the 1960s with the invention of SKETCHPAD [1], CAD systems have become an indispensable tool in the engineering world. It is said that CAD user's overall productivity can be as much as 3 to 5 times better than those using manual drafting [2]. This translates to shortening of product development cycle and a reduced time-to-market. With increasing processing power and decreasing price of computers, CAD systems can now be run on personal computers or workstations to do what used to be only achievable on expensive mainframe computers previously. Today it is rare to find engineering firms without a CAD system running on their computers.

There are many types of CAD systems available in the market, each using a different method of modelling. A two-dimensional (2D) system is comparable to hand drafting with the added advantage of ease of dimension adjustment. Three-dimensional (3D) systems, on the other hand, combine geometric modelling and come with more variants. Wireframe modelling is a 3D modelling which extends from 2D drafting. It makes use of points and lines to create a skeletal model, which has no surface properties [3]. Surface modelling creates 3D models by mathematically defining the surfaces. Constructive solid geometry (CSG) uses basic three-dimensional geometric elements to form solids using Boolean operations, while boundary representation (B-rep) defines the solid through how individual details such as faces and vertices are joined together [4].

Today, CAD software packs more functions than just drafting. New CAD packages are bundled with features such as product lifecycle management (PLM) and product data management (PDM) which links to the bill of materials (BOM) and directly connects to the supply chain [5]. New functions such as automatic hatching, chamfering, lip and groove tool, among others, further reduce design time. Also, some CAD packages come with photo rendering and finite element analysis (FEA) modules, which expand the role of CAD software in the product development process.

This term paper will look into the application of CAD in virtual prototyping in the automobile industry.

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CAD in automobile industry

Traditionally, large corporations such as those in the automobile industry have been able to extensively harness CAD in their product development process due to the availability of capital resources [6, 7]. In the September 3, 2008 issue of Professional Engineering magazine, Lee Hibbert reported on carmakers Jaguar and Land Rover’s £2 million investment into the new virtual reality centre [8].

The Computer Aided Virtual Environment, or more affectionately dubbed the “cave”, is located in Jaguar Land Rover’s Design and Engineering Centre in Gaydon - Warwickshire, UK. It was set up with the aim of helping engineers and designers speed up the product development cycles by reducing the need for physical prototypes, and in the process saving time and money.

It is not as simple as enlarging a CAD drawing and showing it on a large projection screen. Built in a four-walled room, the system uses cutting edge projection technology in the form of eight ultra-high resolution projectors. The projector setup produces photo quality interactive 3D imagery whose ultra-high resolution is four times the definition of full high definition (HD) television. Together with the 3D glasses, viewers are able to experience great realism in 360 degrees when viewing the CAD image. Interactivity between user and the drawing is provided by advanced motion tracking of the user’s head and hands, processed through virtual reality software to adjust the CAD images to the user’s orientation.

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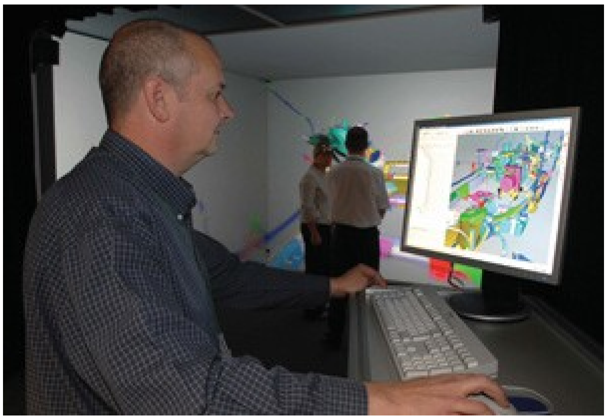

CAD drawings from computer to projector

To use the “cave” system, first the required car part or the whole car has to be created on a CAD system. The CAD drawing is then projected using the ultra-high resolution projector setup. With the help of a handheld wand, users can manipulate the image in various ways. For example, users can “flip” the car around, “lift” it up so that the underside is exposed, or “fly” in mid air so that the top view of the car can be observed. Also, apart from the exterior view, individual drawing parts can be cut away, exposing interior components that are normally hidden from eyes’ view. For example, the user can cut away the car body, zoom into and “walk through” the engine compartment of the car. This allows engineers to explore and study harder-to-reach parts such as pipes and cablings, and check for fit and interferences.

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User with a handheld wand exploring the car components

Besides the mechanical aspect of car design, the virtual reality “cave” system can also aid in ergonomics design of the car. A physical seat can be placed inside the cave so that the user can simulate the actual environment while sitting inside the car interior. Users can “touch” the dashboard console buttons with their hand and a visual feedback in the form of colour change at the exact point of contact can tell whether the dashboard layout is within comfortable distance of reach. Users can also check other design aspects such as visual obstruction from headrest, or the angle of view through the various car windows.

A user “driving” in the virtual environment

However, the system is not able to produce and simulate the physical touch and feel of the interior design. As such, a physical prototype can not be totally excluded from the product development cycle.

Conclusion

This application of CAD in virtual prototyping is expected to help reduce the need for physical prototyping, development and testing. Traditionally carmakers have to make physical prototype out of cardboard, clay and wood, which is a time consuming process. With virtual prototyping, kinematic and dynamic analyses can be performed on the design so that it can be fine-tuned before actual physical prototype is made. This saves time wasted from iteration changes, and thus enhances progressive design improvements. If coupled with finite element analysis, the “cave” system would be able to better illustrate crucial failure points in the design, especially those at harder-to-reach locations. According to the report, the introduction of virtual prototyping can trim off three to four months from the average vehicle product development cycle.

Jaguar and Land Rover also expressed the intention of opening up the “cave” facility for market research and customer feedback groups. Designers and potential customers will be able to view the design from different angles, interior and exterior, in different colours and other variations. This will help the carmaker in updating and developing their car designs more responsively to customer trends and needs. All these result in the carmaker able to produce the new vehicles on a much quicker timeline, a shorter time-to-market and also designs that incorporate customer inputs.

From this case study we can see that CAD system when combined with other technologies, in this case projection and virtual reality technology, can increase the performance and efficiency of product development. While other carmakers may follow suit, I see this technology applicable to other sectors such as aerospace and offshore industries. The “cave” environment can be used to simulate the interior design of an aircraft’s cabin, or its machinery such as the turbine, or it can be used to run through the piping designs of oil and gas processing facilities. There are numerous applications and endless possibilities.

In time to come, virtual prototyping at this scale may become the industrial norm.

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